# MEDICAL CONDITIONS AMONG HOSPITALIZED OLDER ADULT DRIVERS

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Motor-vehicle related deaths and injuries are a significant concern for older adults. In 2007, unintentional injuries, including motor-vehicle related injuries, represented the 9th leading cause of death, and the 4th leading cause of injury for adults 65 and older. And as seniors are living longer and an increasing proportion continue to drive at later ages, functional and medical conditions, related to driving performance and crash risk, have received renewed attention. A number of medical conditions are considered to impact driving performance and have been linked to increased crash risk. There is a general lack of knowledge on the prevalence of these driving-related medical conditions among the older adult drivers population, including those involved in crashes. This study is an attempt to estimate the prevalence of driving-related medical conditions among crash-related hospitalized older adults, and determine role of driving-related conditions on in-hospital death. Furthermore, a matched case-control dimension of this study compares the prevalence of driving-related medical conditions among hospitalized drivers to two control groups, those in knee replacement surgeries as well as those in other most frequent elective procedures, matched on key demographic factors.

The public health significance of this research is its findings on the prevalence of medical conditions among hospitalized older drivers, its results that driving-related conditions are not uniformly overrepresented among hospitalized drivers and that drivers with cardiovascular conditions are significantly more likely to die in-hospital, following a motor-vehicle crash, than those

without such conditions. These results inform stakeholders on the health characteristics of older drivers to guide policies that ensure the safe mobility of this population in an aging society.

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# 1.0 INTRODUCTION

Motor-vehicle related deaths and injuries are a significant concern for older adults. In 2007, unintentional injuries, including motor-vehicle related injuries, represented the 9th leading cause of death, 2nd leading cause of injury death and the 4th leading cause of injury for adults 65 and older (CDC 2011). By 2030 a 155% increase is expected in the number of older drivers and a 180% increase in MV-related injuries (Lyman, Ferguson et al. 2002) with significant consequences for future disability. In 2005, some 47.5 million US adults (21.8 %) reported a disability (CDC 2005) and MV-related injuries are shown to result in significant post-crash disability, accounting for 25% of limitations in activities of daily living (ADL) among those with injury-related chronic disabilities (Guerrero JL 1999). This problem is especially relevant for older adults as in 2009 alone, some 175,000 adults 65 and older were admitted to emergency departments due to MV related injuries, with another 31,000 further transferred or hospitalized (CDC 2011). In that same year 4,396 adults 65 and older were killed as drivers of a motor vehicle in-transport (NHTSA 2011). Since 2001, some 1.4 million older adults have received emergency department (ED) treatment (CDC 2010) and over 64,000 have died due to motor vehicle (MV) injuries (NHTSA 2009).

## 1.1 DRIVING-RELATED MEDICAL IMPAIRMENTS

In 2005, some 47.5 million US adults (21.8 %) reported a disability (CDC 2005) with the number of Americans with disability having increased to 54.4 million by 2008 (USCENSUS 2012). And as seniors are living longer and an increasing proportion continue to drive at later ages (He, Sengupta et al. 2005), functional and medical conditions, related to driving performance and crash risk, have received renewed attention. One study estimate that by 2030, drivers 65 and older will account for 25% of drivers in fatal crashes (Lyman, Ferguson et al. 2002), up from 14% in 2007 (NHTSA 2008) given that older people are at risk of physical and cognitive performance deficits that may compromise the ability to drive safely (Owsley, Ball et al. 1991; Stutts, Stewart et al. 1998; Oxley, Charlton et al. 2005; Classen, Horgas et al. 2008; NHTSA 2008). Physical abilities, such as muscle strength and neck flexibility, are also required to scan surroundings and safely operate a vehicle in traffic (Staplin, Lococo et al. 2003; Shinar 2007).

While no single study has characterized the role of all driving-related medical conditions on crash risk among the US population, a 2000 study by Dischinger et al. examined crash culpability based on a number of medical conditions among adult hospitalized drivers in the state of Maryland. The study showed that mental disorders were most prevalent among this sample, with 25.1 % of drivers having a pre-existing mental disorder, 20.6% having a circulatory condition and 6.8% having muscoskeletal condition. More than 17% of the sample had more than 3 medical conditions, also reporting the highest crash culpability among those with any medical condition (Dischinger, Ho et al. 2000). Other studies have examined more narrow groups of conditions and interactions with crashes or driving performance. Some have examined

the interaction between cognitive conditions such as Mild Cognitive Impairment (Wadley, Okonkwo et al. 2009), dementia and dementia of the Alzheimer type (Parasuraman and Nestor 1991; Rizzo, McGehee et al. 2001; Duchek, Carr et al. 2003; Uc, Rizzo et al. 2005) and driving performance and crash risk among older adults (Brown and Ott 2004; Berndt, Clark et al. 2008). Other studies have examined the role of conditions such as diabetes (Sagberg 2006; Songer and Dorsey 2006; Redelmeier, Kenshole et al. 2009) on crash risk, vision and hearing loss and driving performance (Richardson and Marottoli 2003), reaction time (Margolis, Kerani et al. 2002). Others still have examined the role of cardiovascular conditions and at-fault crash rates (McGwin, Sims et al. 2000).

Significant attention has been also paid to cerebrovascular conditions, inducing stroke (Legh-Smith, Wade et al. 1986; Fisk, Owsley et al. 2002) as well as role of sleep disorders on crashes (Connor, 2001)(Connor, Norton et al. 2001; Connor, Whitlock et al. 2001) (Garbarino, Nobili et al. 2001). The section below provides an abbreviated review of studies examining driving performance, crashes or driving with driving-related conditions as identified by the American Medical Association and the National Highway Traffic Highway Association (AMA 2004; AMA 2010).

### 1.1.1 Vision and hearing loss

Vision and hearing-related conditions that are known to decline with age, and subsequently pose risk to vehicle operation include declines in visual abilities needed to detect road hazards (Richardson and Marottoli 2003), reaction time to adapt to changing traffic patterns (Margolis, Kerani et al. 2002) and visual-spatial perception needed to evaluate traffic patterns accurately

(Braitman, Kirley et al. 2007; Shinar 2007). Owsley et al. (1998) showed that restricted useful field of view and glaucoma were significant independent predictors of injurious crash involvement among older drivers (Owsley, McGwin et al. 1998). Others showed that driver's visual processing, history of falls and self-reported medical conditions were predictors of older driver's at-fault crash involvement (Sims, Owsley et al. 1998). Specifically, studies have shown that visuo-spatial processing is related to declines in driving-related response time (Zhang, Baldwin et al. 2007) and that visual depth impact on driving safety and driving performance (Owsley and McGwin 1999) and that visual-perception shows association with aspects of driving performance.

### 1.1.2 Cardiovascular disorders

The American Medical Association and National Highway Traffic Safety Administration identify a number of cardiovascular and cerebrovascular disorders considered to be associated directly with increased crash risk or associated with declines in driving performance (AMA 2010). These conditions include unstable coronary syndrome, cardiac condition that may cause loss of consciousness, cardiac disease such as congestive heart failure (CHF), valvular disease and others (AMA 2010). According to the AMA, cardiovascular conditions may results in prolonged chest discomfort, acute shortness of breath, syncope and other conditions that may impair driving (AMA, 2010).

Specifically, a case-control study by Vernon (2000) examining the crash and citation rates of drivers with medical conditions in Utah showed that drivers with medical conditions had slightly higher averse driving events compared to healthy controls (RR 1.09 to 1.74). Among

those with medical conditions, drivers with cardiovascular conditions did not result in higher than control rates of adverse driving events (Vernon, Diller et al. 2002). On the other had a study by McGwin et al. (2000) examining the relationship between chronic medical conditions and automobile crashes among older drivers showed that older drivers with heart disease were 1.5 times as likely as driver without heart disease to have been involved in crashes. Similarly, drivers with histories of stroke were 1.9 more likely to be involved in at-fault automobile crashes than those without such a condition (McGwin, Sims et al. 2000).

Ventricular arrhythmias are another set of cardiovascular conditions specifically examined, given its association with ventricular fibrillation, asystole or sudden death. Experts have argued that it is not sufficiently clear what the risks for crash involvement is among drivers with ventricular arrhythmias, as many factors related to crash risk are unknown (Epstein, Baessler et al. 2007). But some have shown that among patients with implantable cardioverter-defibrillator (ICD) in those with ventricular arrhythmias, ICD discharges occur 10% of the time, while the patients are driving, resulting in an accident (Curtis, Conti et al. 1995). In a study by Epstein (2007), which examined crash risk among drivers with ventricular arrhythmias, who also had ICD's showed that their risk of harm to themselves or others, was 0.0000224 percent (1 per 45,000 ICD discharges/incidents) indicating very low risk (Epstein, Baessler et al. 2007).

### 1.1.3 Cerebrovascular disorders

Cerebrovascular disorders, including stroke, among the driving population, have received considerable attention. According to CDC, in 2005, stroke was identified as the 10$^{th}$ leading cause of disability among non-institutionalized US adult population, accounting for 2.2 percent

of disabilities or disabling some 1,076,000 adults. Notably, this condition is significantly more prevalent among older adults (CDC 2005). Among adults 65 and older, 8.1 percent reported a history of stroke (CDC 2005).

A 1997 study by Fisk et al. showed that stroke has significant implications for driving post-stroke with only 30% of drivers having continued driving following a stroke. A separate study, reported up to 43% of drivers continued driving post-stroke, with those that continued driving still reporting some stroke-related disability on activities of daily living as well as arm functioning. Also those that ceased driving reported significantly more depression than those that continued driving (Legh-Smith, Wade et al. 1986). Fisk (1997) also showed that medical counseling for stroke survivors was lacking, with 48 percent of sampled stroke survivors reporting not receiving any advice on driving, and 87 percent reporting not receiving any type of driving evaluation following the stroke. While, not directly examining role of stroke in driving-related crashes, this study showed the significant implications of stroke on drivers and their mobility. More directly examining causes of crash, a study examining police reported crashes, involving "collapse at wheel", showed that some 38% of such identified crashes were due to epilepsy, followed by 21% due to blackouts, with diabetes on insulin accounting for 18% of these crashes, and heart conditions and stroke accounting for another 8% and 7% respectively (Petch 1998). A separate study showed that neutrally mediated syncope was the most common type of syncope while driving, and cardiac arrhythmias being the 2$^{nd}$ most frequent cause. This study also showed that risk of syncope while driving was related to patient's history of cardiovascular disease and stroke (Sorajja, Nesbitt et al. 2009).

### 1.1.4 Neurologic diseases – Dementia

The group of neurologic diseases though to be related to driving performance is extensive. The AMA/NHTSA guidebook lists brain tumor, head injury, dementia, Parkinson's disease, seizure disorders, stroke and sleep disorders, among others (AMA 2010). However, it is dementia that has received the most scientific attention. Studies reported that drivers with dementia of the Alzheimer's type (AD) report declines in attention performance, especially when switching between targets for visual selective attention. These types of declines in information-processing tasks related to attention are shown to be related to motor-vehicle crash rates (Parasuraman and Nestor 1991). Others further reported that older drivers with mild to severe Alzheimer's disease (AD) differed from study controls in driving exam performance and were deemed as unsafe drivers (Hunt, Morris et al. 1993). Subsequently, in a study by Tuokko et al. (1995) adult drivers with dementia were found to have 2.5 times the motor vehicle crash risk of their matched controls (Tuokko, Tallman et al. 1995). Similarly a matched case-control study by Drachman et al., (1993) reported that drivers with AD had twice the annual crash rate than matched controls with an average of 0.09 crashes per year compared to 0.04 crashes per year for study controls (Drachman and Swearer 1993).

A review of published studies on driving safety of older adults with dementia showed that drivers with probable AD with a Clinical Dementia Rating (CDR) of 0.5 had mildly impaired driving performance. Authors argued that mildly impaired driving performance is within the levels tolerated for other driving groups. Furthermore, this review noted that it was drivers with AD and a CDR of 1 that presented significant safety concerns due to both their poor driving performance and their crash history (Dubinsky, Stein et al. 2000). These conclusions were

further supported by a longitudinal study of driving performance of older drivers with dementia by Duchek et al. (2003). Duchek concluded that those with a CDR rating of 1 received an unsafe driving performance rating much earlier than those with a CDR score of 0 or 0.5 (Duchek, Carr et al. 2003). Other studies have provided additional support with a recent study by Ott et al. (2008) reporting that drivers with AD experienced a higher number of accidents and performed worse on road tests than controls. Furthermore, the driving performance of those with AD declines quicker than study controls (Ott, Heindel et al. 2008).

While a number of studies concluded that mild to severe AD resulted in poorer driving performance, others examined drivers with very mild AD and mild cognitive impairments such as those with traumatic brain injuries (TBI). A study by Wadley and colleagues (2009) showed that drivers with mild cognitive impairments (MCI) showed significantly lower driving performance when compared to controls on various driving maneuvers. However this study also concluded that the poor performance of MCI drivers would not amount to a driving impairment. However, given the likelihood of progression of MCI into dementia, authors argue that drivers with MCI require additional attention for further changes in driving performance (Wadley, Okonkwo et al. 2009). Similar conclusions were reached by a study by Berndt and colleagues in 2008. They noted that drivers with negligible dementia were able to pass on-road driving assessments whereas those with moderate dementia failed (Berndt, Clark et al. 2008).

Longitudinal studies also showed that those with Alzheimer's disease, were shown to have a significantly faster rate of being rated as not safe drivers due to declines in their driving skills, compared to normal controls, however the rate of decline varied significantly with age (Duchek, Carr et al. 2003).

### 1.1.5 Sleep disorders

Sleep disorders, including narcolepsy and sleep apnea, are two other conditions often associated with crash risk among drivers. Among drivers in New Zealand, symptoms related to sleep apnea (snoring, choking, breathing pauses) were present in 1.6 percent of a random-population sample of drivers (Connor, 2001). However, among this sample, more than 21 percent of the sample reported less than 5 hrs of sleep, a significant factor for impaired alertness (Connor, Norton et al. 2001; Connor, Whitlock et al. 2001). Others have shown that up to 3.2 percent of crashes examined were directly attributed to sleep-related issues, among which some 11.4 percent of crashes resulted in a driver fatality, in contrast to 5.6 percent fatality among crashes with not related to sleep (Garbarino, Nobili et al. 2001). Garbarino further estimates that the proportion of crashes in one way or another related to sleepiness may be as high as 21.9 (95 % CI 19.8; 24.0) accounting for the number of vehicles involved (Garbarino, Nobili et al. 2001). Others show that when comparing crash risk among drivers with high sleepiness scores on the Epworth Sleepiness Scale and Functional Outcomes of Sleep Questionnaire) to controls, increasing sleepiness was related to increasing accident risk, with the sleepiest 5 percent having 1.9 times the risk of study controls and 2.67 the risk of being involved in multiple accidents (Howard, Desai et al. 2004).

### 1.1.6 Musculoskeletal disabilities

Physical performance among patients with lower extremity injuries or disabilities is another area examined regarding its role on driving performance. Musculoskeletal disabilities may decrease motor strength, compromise range of motion and thus result in increased risk of crash (AMA,

2010). Studies among drivers with anterior cruciate ligament (ACL) reconstruction showed that brake reaction time matched that of healthy controls within 4-6 weeks, indicating that the impact of this condition on a crucial driving function is transient. Among patients with ACL reconstruction, it was advised that physicians measure reaction time before recommending return to driving (Gotlin, Sherman et al. 2000). Others have examined driving-related reaction following total hip replacement and shown that using simulated driving control system, patients with total hip replacement perform significantly worse than healthy controls as well as compared to their pre-operative performance. However, most patients with total hip replacement return to pre-operative driving performance levels within 8 weeks, while some showed significantly worse driving performance up to 8 months post operation (MacDonald and Owen 1988). Additionally, arthritis was shown to be associated with an 1.8 times increased risk among female drivers and at-fault crash rate of drivers with arthritis was 20 percent higher than among drivers without arthritis (McGwin, Sims et al. 2000).

### 1.1.7 Metabolic disorders

According to CDC, in 2005, diabetes was identified as the 6$^{th}$ leading cause of self-reported disabilities among adult non-institutionalized US population. Diabetes accounted for 4.5 (95% CI 4.0-5.0) or 2,010,000 disabilities among the US population (CDC 2005). According to the AMA, individuals in acute phases of metabolic disorders may experience symptoms that compromise their driving ability (AMA, 2010). It has been shown that drivers with type 1 diabetes often overestimate blood glucose (BG) for safe driving, are not aware of their low BG levels and often would drive even when aware of their low BG levels (Clarke, Cox et al. 1999).

Others have shown that simulator driving performance was significantly impaired among hypoglycemic BG levels. Furthermore, as also noted by Clarke, (1999) a study by Cox et al., (2000) showed that patients, aware of the detrimental effect of low BG levels on their driving, failed to take any corrective measures (Cox, Gonder-Frederick et al. 2000). Studies argue that patients during acute phases of diabetes may be impaired to drive and possibly at increased crash risk (Weinger, Kinsley et al. 1999; Cox, Gonder-Frederick et al. 2000).

In a recent study by Songer et al., (2006) no significant relationship were found between diabetes complications, blood glucose control, diabetes treatment and subsequent motor vehicle crashes (Songer and Dorsey 2006). Similarly, as reported by McGwin et al., (1999), there was no association between diabetes and at-fault crash involvement (McGwin, Sims et al. 1999). However, it is noted that type 1 diabetes has worsening outcomes over time, whereby crash outcomes among those with diabetes may change over time (Songer and Dorsey 2006). Others have argued that drivers with diabetes mellitus have slightly increased risks of traffic accidents as compared to controls (Hansotia and Broste 1991). As noted by Dobbs (2005) summary of literature on role of diabetes on crashes lacks consensus (Dobbs 2005).

# 2.0 METHODS

## 2.1 DATA SOURCES AND STUDY DESIGN

### 2.1.1 Data sources

This study uses the 2007 Nationwide Inpatient Sample (NIS). The NIS is a stratified probability sample of U.S. hospitals, sponsored by the Agency for Healthcare Research and Quality (AHRQ) (AHRQ, 2007). The NIS is the largest all-payer inpatient care database, containing data from 5 to 8 million hospital stays from about 1,000 sampled U.S. community hospitals (AHRQ 2007). This study uses weighted or national estimates. Reported information reflects weighted national estimates, unless stated otherwise. Additional details on how NIS data is collected can be found on the AHRQ website. This study was categorized as exempt by the University of Pittsburgh institutional review board because it uses a public database without individual identifiers. SAS V.13 (Cary, NC) was used for analyses and to generate 95% confidence intervals for weighted estimates.

### 2.1.2 Case selection

In this study, motor vehicle related hospitalizations were identified based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) external cause of injury coding (E-Codes: E810-819) and fourth digit of 0, denoting a driver, in any of the first four E-Code fields. Hospitalized adults, identified as drivers, of a motor-vehicle crash that occurred in traffic, were selected as cases. In order to reduce the possibility of double counting hospitalized individuals, patients admitted as a transfer from other hospitals were excluded from this analysis. This approach is consistent with other studies (Bowman, Bird et al. 2008).

### 2.1.3 Control selection

In addition to reporting the prevalence of driving related medical conditions among hospitalized drivers, this study compares those estimates to those of two control populations. Two controls were selected to best approximate the prevalence of medication conditions among non-crashed drivers. However, as the medical histories of non-crashed populations were not available, hospitalized adults for elective procedures were selected as best groups to serve as proxies for driving adults from the community, not in a crash-related hospitalization. Two separate controls were also selected to reduce the likelihood of the threat to external validity, termed "Berkson's Bias" whereby the selected groups of controls significantly differ from the source population of study cases. By selecting two control groups, the study will seek to find consistencies in results between comparisons to both control groups.

The first control is composed of patients hospitalized for elective knee replacement surgery. Elective knee replacement surgery procedures were selected based on the Agency for Healthcare Research and Quality's (AHRQ) Clinical Classification Software (CCS), with CCS procedure code of knee anthroplasty. As with study cases, study controls were excluded if patient was admitted from another hospital. Of the approximately 319,512 elective knee replacement hospitalizations identified, a total of 23,993 elective knee replacement controls were identified following the matching process.

The second control group was composed of the most frequently reported elective surgical procedures among hospitalized adults. These procedures included procedures of transurethral resection of prostate (TURP), coronary artery bypass graft (CABG), hip replacement; total and partial, arthroplasty knee, percutaneous transluminal coronary angioplasty (PTCA), cholecystectomy and common duct exploration, inguinal and femoral hernia repair, lens and cataract procedures, varicose vein stripping; lower limb, tonsillectomy and/or adenoidectomy.

### 2.1.4 Design and matching

This study uses a matched case-control design with hospitalized older drivers matched to hospitalized controls, described above, on age at admission (+/- 2 years), race/ethnicity, gender, insurance status and income level at patient's zip code. To ensure successful matching, the matching process was repeated two times, yielding similar matching results. This study attempted to match two controls, for each of the control groups, to one case. Two was chosen as the number of controls, since attempts to match more than two controls on five conditions resulted in a high number of cases not matched. When matching to elective knee replacement

controls on the five matching conditions, of the 20,436 hospitalized older-adult drivers, 13,663 crash-hospitalized cases were successfully matched to at least one controls on the five conditions specified, yielding some 23,993 elective knee replacement controls. Similarly, when matching on hospitalized adults in the most frequent elective procedures, of the 20,436 hospitalized older-adults drivers identified, 14,643 were successfully matched to at least one control, yielding 27,798 controls.

### 2.1.5 Identification of driving-related medical conditions

Physical and cognitive conditions that may affect safe driving were selected based on the American Medical Association (AMA) Physician's Guide to Assessing and Counseling Older Drivers (AMA 2010). ICD-9-CM principal diagnoses and diagnoses up to $10^{th}$ field were used to identify driving-related conditions, grouped into Vision and Hearing loss, Cardiovascular diseases, Neurologic diseases, Cerebrovascular diseases, Metabolic disorders, Muscoskeletal disabilities, and Peripheral Vascular Disorders as specified by the AMA Physician's guide (AMA 2010). The Agency for Healthcare Research and Quality's (AHRQ) Clinical Classification Software (CCS) (AHRQ, 2012) the Charlson Co-morbidity Index (Charlson, Pompei et al. 1987), Elixhauser co-morbidity groupings (Southern, Quan et al. 2004; Zhu and Hill 2008), were used to identify driving-related conditions among MV-related admissions.

### 2.1.6 Injury estimates

Injury diagnoses and procedures were grouped using the Clinical Classifications Software (CCS) for ICD-9-CM. CCS combines individual ICD-9-CM diagnosis and procedure codes into broader diagnosis and procedure categories (Agency for Healthcare Research and Quality). Injury severity is calculated utilizing the algorithms of the Injury Categorization (ICDPIC) Program provided by the American College of Surgeons which translates ICD diagnosis codes into Abbreviated Injury Scores (AIS) and Injury Severity Scores (ISS) (Clark, Hahn et al. 2008). The ICDPIC algorithms are applied to NIS database to derive aforementioned injury scores. NIS does not provide injury scoring of hospitalized patients. Furthermore, Injury Severity Scoring that ranges from 1 to 75 was grouped into 3 categories in order to assure model fit, as its natural distribution is not normal. While there is no standard grouping of injury severity score values, this study uses the following groups: ISS 1-9, 10-19 and scores 20 and above, based on published literature (Osberg and Scala 1992 ).

### 2.1.7 Traumatic brain injury

Traumatic brain injury is defined and selected on the basis of a TBI-related diagnoses in any of the first 10 diagnosis fields in accordance with ICD codes specified by the CDC TBI surveillance case definition (Thurman, Sniezek et al., 1995). The CDC TBI case definition includes ICD-9-CM diagnosis codes 800.0-801.9, 803.0-804.9, and 850.0-854.1. TBI-related long term disability is estimated using a model developed by Selassie et. al. based on the South Carolina Traumatic

Brain Injury Follow-up Registry (SCTBIFR) (Selassie, Zaloshnja et al. 2008). Additional detail in the SCTBIFR can be found in a study by Pickelsimer et al., (2007).

## 2.2 STATISTICAL METHODS

First, national estimates on the prevalence of driving-related medical conditions are calculated, based on identified conditions among hospitalized drivers. Characteristics of these medical conditions among patient groups are presented. Second, conditional logistic regression is used to examine the risk of a crash-related hospitalization when compared to matched controls consisting of adults hospitalized for elective knee replacement procedures and a control group consisting of hospitalized adults for most frequent elective procedures, detailed below. To assess multicollinearity among independent predictors in the multivariate model, Variance Inflation Factor (VIF) was used. A high VIF value (>4) for neurological conditions was detected due to its high correlation (r=0.80) with a dementia diagnosis. Dementia was used in the final model, with the grouping of neurological conditions removed from the model. Subsequent model indicated VIF values below 2.5. Similarly, diagnostic testing on final multivariate model yielded tolerance values nearing 1.

Third, one main outcome, in-hospital death, is examined as predicted by driver's medical conditions, when adjusting for number of diagnoses, age, gender, race and income. Data of in-hospital death, as the first outcome, was analyzed using logistic regression, using the survey logistic function of SAS, accounting for the non-random sampling of NIS data. NIS survey weighting for variance adjustment are provided in NIS documentation.

# 3.0 RESULTS

## 3.1 MEDICAL CONDITIONS AMONG HOSPITALIZED DRIVERS

An estimated 20,436 (95% confidence interval [CI], 17,339- 21,803) older adults had motor vehicle crash-related hospital discharges nationwide in 2007. Males accounted for 52.7 percent of cases (95% CI, 51.0-54.4) with drivers aged 65-74 contributing the highest number of cases (43.3%). An estimated 113 drivers aged 95 or older (95% CI, 54-173) were also hospitalized in 2007, accounting for 0.3 percent of hospitalized drivers 65 and older. Some 5.4 percent (95% CI, 4.3-6.6) died during hospitalization, and 46.1 percent (95% CI, 43.9-48.3) were routinely discharged, with another 34.6 percent discharged to short-term, long-term, or other healthcare facilities.

The majority of hospitalized older drivers (82.9%) were White, with another 7.6 percent being Black, and 5.5 being categorized as Hispanic. Some 1.6 percent of hospitalized adult drivers were Asian/Pacific Islander and another 0.7 percent was of Native American origin. Of the total hospitalized older driver population some 20.7 percent of records were missing information on the patient's ethnicity.

With regard to patient's location, 23.8 percent of hospitalized older patients were from "Central" locations of counties with more than 1 million populations, and only 9.4 percent were from areas smaller than 50,000 residents. Primary source of payment was another category that

distinguished hospitalized older patients. Some 37 percent used Medicare as primary source of payment and another 55.3 percent used private insurance /HMO as their primary payer (Table 1).

**Table 1. Patient characteristics and disposition for older driver motor vehicle-related hospitalizations**

| Characteristics | N (95% CI) | % (95% CI) |
|---|---|---|
| **Total estimated number of cases** | 20,436 (18,103- 22,769) | |
| **Gender** | | |
| Male | 10,753 (9,543 - 11,964) | 52.7 (51.0 - 54.4) |
| Female | 9,659 (8,717 - 10,600) | 47.3 (45.6 - 49) |
| **Age group (years)** | | |
| 65-69 | 4,838 (4,200 - 5,476) | 23.7 (22.2 - 25.1) |
| 70-74 | 4,307 (3,788 - 4,826) | 21.1 (19.8 - 22.3) |
| 75-79 | 4,609 (4,071 - 5,148) | 22.6 (21.2 - 23.9) |
| 80-84 | 3,906 (3,479 - 4,333) | 19.1 (17.7 - 20.5) |
| 85+ | 2,776 (2,432 - 3,120) | 13.6 (12.3 - 14.9) |
| **Race** | | |
| White | 13,228 (11,612 – 14,844) | 82.9 (79.2 - 86.6) |
| Black | 1,220 (877 - 1564) | 7.6 (5.7 - 9.6) |
| Hispanic | 870 (455 - 1286) | 5.5 (2.9 - 8) |
| Asian/Pacific Islander | 251 (150 - 351) | 1.6 (1 - 2.2) |
| Native American | 109 (0 - 225) | 0.7 (0 - 1.4) |
| Other | 276 (173 - 379) | 1.7 (1.1 - 2.3) |
| **Patient Location** | | |
| "Central" counties of metro areas of >=1 million population | 4,621 (3,441 - 5,802) | 23.8 (18.6 - 29.1) |
| "Fringe" counties of metro areas of >=1 million population | 4,638 (3,540 - 5,736) | 23.9 (19 - 28.9) |
| Counties in metro areas of 250,000-999,999 population | 3,618 (2,788 - 4,449) | 18.7 (14.5 - 22.8) |
| Counties in metro areas of 50,000-249,999 population | 1,932 (1,429 - 2,436) | 10 (7.4 - 12.5) |
| Micropolitan counties | 2,748 (2,168 - 3,329) | 14.2 (11.7 - 16.7) |
| Not-metropolitan or micropolitan counties | 1,831 (1,482 - 2,180) | 9.4 (7.9 - 11) |

CI, confidence interval

**Table 1. Continued**

| Characteristics | N (95% CI) | % (95% CI) |
|---|---|---|
| **Primary Payer** | | |
| Medicare | 7,520 (6,435 - 8,606) | 37 (32.9 - 41.2) |
| Medicaid | 61 (27 - 96) | 0.3 (0.1 - 0.5) |
| Private Insurance - HMO | 11,229 (9,698 - 12,760) | 55.3 (50.9 - 59.7) |
| Self-Pay | 564 (347 - 780) | 2.8 (1.7 - 3.8) |
| No Charge | 6.784 (0 - 20) | 0 (0 - 0.1) |
| Other | 929 (534 - 1,324) | 4.6 (2.7 - 6.5) |
| **Disposition of patient** | | |
| Routine | 9,412 (8,401 - 10,423) | 46.1 (43.9 - 48.3) |
| Transfer - short-term hospital | 665 (514 - 815) | 3.3 (2.5 - 4) |
| Transfer - other type of facility | 6,745 (5,815 - 7,675) | 33 (31.2 - 34.8) |
| Home health care | 2,320 (1,972 - 2,669) | 11.4 (10.2 - 12.6) |
| Against medical advice | 161 (96 - 225) | 0.8 (0.5 - 1.1) |
| Died in hospital | 1,109 (794 - 1,424) | 5.4 (4.3 - 6.6) |
| Discharged alive, destination unknown | 16 (0.0 - 33) | 0.1 (0 - 0.2) |

CI, confidence interval

### 3.1.1 Principal diagnoses and length of stay

The most frequent principal diagnosis for hospitalized older drivers was fractures of vertebral column, pelvis, rib or other factures, accounting for 22.8 percent (95% CI=21.4-24.4) and grouped as other fractures in the table below. Intracranial, crushing, or internal injuries accounted for another third of principal diagnoses, with some 14.0 (95% CI=12.6-15.4) of principal diagnoses being intracranial injuries and another 10.8 percent (95% CI=9.7-11.8) being accounted by crushing injuries (Table 2). The diagnoses with the longest average hospital length of stay were spinal cord injuries, averaging 14.4 days, and accounting for 1.4 percent (95% CI=1.0-1.9) of principal recorded injury diagnoses.

**Table 2. Injuries among Hospitalized Older Drivers, Length of stay and Charges**

| | | LOS (days) | | |
|---|---|---|---|---|
| | | **Mean** | **Median** | **Sum** |
| **Total estimated cases N (95 % CI)** | 20,436 (18,103- 22,769) | 6.8 | 3.47 | 139,898.0 |
| **Top ten principal diagnoses % (95% CI)** | | | | |
| Other fractures | 22.8 (21.4 - 24.2) | 7.0 | 4.0 | 32,502.1 |
| Intracranial injury | 14.0 (12.6 - 15.4) | 7.2 | 4.0 | 20,625.1 |
| Crushing injury or internal injury | 10.8 (9.7 - 11.8) | 10.4 | 6.0 | 22,942.7 |
| Fracture of lower limb | 10.2 (9.2 - 11.2) | 8.0 | 5.0 | 16,559.9 |
| Superficial injury; contusion | 5.2 (4.4 - 5.9) | 2.6 | 2.0 | 2,753.7 |
| Syncope | 4.0 (3.3 - 4.7) | 3.0 | 2.0 | 2,459.3 |
| Fracture of neck of femur (hip) | 2.1 (1.7 - 2.5) | 10.4 | 7.0 | 4,430.2 |
| Other injuries | 2.0 (1.5 - 2.5) | 2.6 | 2.0 | 1,073.1 |
| Cardiac dysrhythmias | 1.8 (1.3 - 2.2) | 5.2 | 4.0 | 1,894.2 |
| Spinal cord injury | 1.4 (1.0 - 1.9) | 14.4 | 9.0 | 4,249.5 |
| **Hospital location** | | | | |
| Rural | | 4.9 | 3.0 | 12,328.8 |
| Urban nonteaching | | 5.3 | 4.0 | 34,156.4 |
| Urban teaching | | 8.1 | 4.0 | 93,074.3 |

CI, confidence interval

### 3.1.2 Estimated injury severity, brain injury and medical conditions

When examining the prevalence of Traumatic Brain Injury (TBI) among hospitalized older adults, some 13.41 of those 65 to 69 were diagnosed with injuries to the head that fall within the spectrum of TBI (95% CI: 11.03- 15.79). This declined to 12.09 percent among those hospitalized drivers ages 85 and older (95% CI: 8.9- 15.28). Long-term disability estimates due to TBI, applied to this data, were derived from the South Carolina Traumatic Brain Injury Follow-up Registry (SCTBIFR). Based on these estimates, disability is defined as "having 1 or more of the following: (a) functional limitation in at least 1 of the ADLs [activities of daily

living]; (b) significant post-injury symptoms that limited activities (c) significant cognitive complaints, that is, scores that were 2 SDs above the population norm (≥22.2); or (d) significant problems in mental health, that is, scores that were 2 SDs below the population norm (≤30)" (Selassie, Zaloshnja et al. 2008). Results show that following a crash, hospitalized older adults ages 65 to 69 have a 54% probability of disability, as defined above, which increases to 66% for hospitalized drivers ages 85 and older, this even though older adults are found to have less severe injuries, as measures by either the Injury Severity Score (ISS) or the New Injury Severity Score (NISS). Both ISS and NISS, calculated using the ICDPIC module that translates ICD9 coding into standard injury scoring, decrease with age. The average NISS score for hospitalized drivers 65 to 69 is 10.52, which declines to 9.9 for drivers ages 85 and older. The ISS, which is the sum of squares of the highest Abbreviated Injury Score (AIS) for 3 most injured body regions, similarly declines from 8.7 for those 65 to 69 to a score of 8.2 for those ages 85 and older. Estimates for two other measures, Survival Risk Ratios (SRR) and Independent Survival Rate Ratio (SRRi), calculated using ICDPIC when applied to NIS data are presented below. The first measure, Survival Risk Ratios presents the ratio of patients surviving following trauma for the specified age groups based on trauma codes corresponding to patient's injury diagnosis.

Similarly, the Independent Survival Rate Ratio (SRRi) presents the ratio of patients surviving following trauma for the specified age groups, calculated when patient record has only one injury diagnosis corresponding to a trauma code. These measures show that both SRR and SRRi are relatively consistent across the age groups, with SRR showing little increases from 65-69 year olds, of whom 75 percent are expected to survive the crash injuries [SRR = 0.75; 95% CI 0.73- 0.76] to 76 percent for those ages 85 and older [SRR = 0.76; 95% CI 0.74- 0.78]. Similarly, SRRI shows that for those hospitalized adults with single trauma codes, 88 percent are expected

to survive for those ages 65 to 69 [SRRi = 0.88; 95% CI 0.88- 0.89], increasing to 89 percent for those 85 and older [SRRi = 0.89; 95% CI 0.88- 0.9].

Examining the prevalence of medical conditions among hospitalized drivers, metabolic conditions and respiratory conditions represented two condition groups with the highest prevalence among hospitalized drivers. Some 26.1 percent of hospitalized drivers ages 65 to 69 had a metabolic condition (95%: 22.88-29.27), which included uncomplicated diabetes, diabetes with complications or hypothyroidism. The prevalence of metabolic conditions among hospitalized drivers declined to 11.3 percent for those ages 85 and older (95%: 7.01- 12.49). Similarly, respiratory conditions declined from 10.84 percent among those 65 to 69, to 6.54 percent among hospitalized drivers ages 85 and older (95% CI: 4.45- 8.64).

Neurologic diseases, that include Dementia, Alzheimer's disease, Parkinson's diseases, Huntington's disease, or other cognitive deficits were identified among 4.08 percent of hospitalized adults 65 to 69 (95% CI: 2.94- 5.22) increasing to 11.21 percent among drivers ages 85 and older (95% CI: 8.69- 13.72). A diagnosis of dementia, specifically, was present for 2.23 percent of hospitalized drivers 65 to 69 (95% CI: 1.27 - 3.18), increasing to 9.6 percent among drivers 85 and older (95% CI: 7.13-12.07).

Conditions of vision and hearing loss also increased in prevalence with increasing age. Among hospitalized drivers ages 65 to 69, some 2.26 percent had a condition of vision or hearing loss, which included Glaucoma, Hemianopia/Quadrantanopia, Monocular vision, Cataract or other conditions (95% CI: 1.33- 3.19). The presence of a vision or hearing conditions increased to 5.3 percent for those ages 85 and older (95% CI: 3.5- 7.11). Furthermore, cardiovascular conditions, typified by congestive heart failure, High grade atrio-ventricular (AV) block, Valvular Disease or other conditions, was present in 6.93 percent of drivers ages 65 to 69 (95%

CI: 5.37- 8.50) and increased to 10.34 percent for drivers ages 80 to 84 (95% CI: 8.10- 12.59) before declining to 9.75 percent, among drivers 85 and older (95% CI: 7.01- 12.49). Cereborvascular conditions, including stroke, separate from cardiovascular diseases illustrated below were omitted due unreliable estimates (Table 3).

**Table 3. Injuries and Prevalence of Driving-Related Medical Conditions among Hospitalized-Drivers**

| | 65-69 | 70-74 | 75-79 | 80-84 | 85+ |
|---|---|---|---|---|---|
| **Total estimated cases** | 4,838 (4,200; 5,476) | 4,307 (3,788; 4,826) | 4,609 (4,071; 5,148) | 3,906 (3,479; 4,333) | 2,776 (2,432; 3,120) |
| **Injuries and Predicted Disabilities** | | | | | |
| New Injury Severity Score (NISS) (Mean) | 10.52 (9.82- 11.21) | 10.36 (9.63- 11.09) | 10.22 (9.43- 11) | 9.9 (9.23- 10.56) | 9.97 (9.14; 10.81) |
| Injury Severity Score (Mean) | 8.7 (8.12- 9.28) | 8.58 (7.97- 9.2) | 8.69 (8.05- 9.32) | 8.35 (7.78- 8.91) | 8.17 (7.52- 8.83) |
| TBI (%) | 13.41 (11.03- 15.79) | 12.1 (9.38- 14.83) | 13.42 (11.11- 15.73) | 12.12 (9.68- 14.56) | 12.09 (8.9- 15.28) |
| Probability for disability (TBI) (Mean) | 0.54 (0.52- 0.56) | 0.56 (0.54- 0.58) | 0.61 (0.59- 0.63) | 0.66 (0.64- 0.68) | 0.66 (0.64- 0.68) |
| Survival Rate Ratio (Mean) | 0.75 (0.73- 0.76) | 0.75 (0.74- 0.77) | 0.76 (0.74- 0.77) | 0.77 (0.76- 0.79) | 0.76 (0.74- 0.78) |
| Ind. Survival Rate Ratio (SRRi) (Mean) | 0.88 (0.88- 0.89) | 0.88 (0.87- 0.89) | 0.89 (0.88- 0.9) | 0.89 (0.88- 0.9) | 0.89 (0.88- 0.9) |
| **Driving Related Conditions (1-10 Dx)^** | | | | | |
| No driving-related condition | 54.47 (51.54- 57.39) | 56.16 (52.65- 59.67) | 54.65 (51.5- 57.8) | 54.2 (50.72- 57.68) | 61.47 (57.46- 65.48) |
| Vision and Hearing Loss | 2.26 (1.33- 3.19) | 2.82 (1.73- 3.9) | 3.29 (2.15- 4.42) | 3.14 (1.83- 4.45) | 5.3 (3.5- 7.11) |
| Cardiovascular Diseases | 6.93 (5.37- 8.50) | 8.77 (6.82- 10.73) | 10.14 (8.1- 12.18) | 10.34 (8.1- 12.59) | 9.75 (7.01- 12.49) |
| Neurologic diseases | 4.08 (2.94- 5.22) | 6.49 (4.92- 8.07) | 7.35 (5.57- 9.13) | 10.36 (8.05- 12.67) | 11.21 (8.69- 13.72) |
| *Dementia* | 2.23 (1.27 - 3.18) | 3.66 (2.42- 4.86) | 5.81 (4.15- 7.47) | 7.58 (5.75-9.42) | 9.60 (7.13-12.07) |
| Metabolic Disorders | 26.07 (22.88- 29.27) | 23.58 (20.63- 26.52) | 22.31 (19.54- 25.07) | 19.76 (16.84- 22.68) | 11.35 (8.84- 13.87) |
| Musculoskeletal Disabilities | 1.36 (0.64- 2.08) | 1.11 (0.44- 1.78) | 1.67 (0.67- 2.66) | 1.08 (0.33- 1.83) | 0.92 (0.24- 1.61) |
| Peripheral Vascular Disorders | 1.83 (0.96- 2.69) | 1.77 (0.92- 2.62) | 1.97 (1.06- 2.89) | 1.99 (0.91- 3.07) | 1.71 (0.67- 2.74) |
| Renal Disease | 1.54 (0.74- 2.34) | 1.87 (0.87- 2.87) | 1.28 (0.58- 1.99) | 0.31 (0- 0.74) | 0.58 (0.12- 1.05) |
| Respiratory Diseases | 10.84 (8.98- 12.71) | 9.06 (7.21- 10.92) | 8.74 (6.83- 10.65) | 8.87 (6.81- 10.93) | 6.54 (4.45- 8.64) |

^patients may have more than one condition within the group

Survival Rate Ratio (Indicates probability of survival)

## 3.2 MEDICAL CONDITIONS AMONG HOSPITALIZED DRIVERS COMPARED TO HOSPITALIZED COMPARISON GROUPS

### 3.2.1 Univariate comparisons

In univariate comparisons with matched patients hospitalized for elective knee replacements, driving-related medical conditions did not show a uniform association with crash-related hospitalizations. Vision and hearing loss conditions were associated with a reduced risk of crash-related hospitalization compared to elective knee replacement patients [OR=0.68; 95% CI: 0.64 – 0.72]. Similarly, metabolic diseases and musco-skeletal diseases showed a strong association with a lower risk of crash-related hospitalization [OR=0.90; 95% CI: 0.87 – 0.92 and OR=0.44; 95% CI: 0.42 – 0.46, respectively]. On the other hand, cardiovascular diseases and dementia, as a measure of neurologic diseases, were two condition groups which showed a significant association with an increased risk of a crash-related hospitalization. Individuals with cardiovascular disease had 42% higher risk of a crash-related hospitalization, when compared to matched elective knee replacement controls [OR=1.42; 95% CI: 1.36-1.48] and those with a diagnosis of dementia, a neurologic disease, had 239% higher risk of a crash-related hospitalization [OR=2.39; 95% CI: 2.24-2.55]. Peripheral vascular disease, renal disease and respiratory disease were associated with an increased crash-hospitalization risk when compared to elective knee replacement controls [OR=1.17; 95% CI: 1.07-1.28, OR=5.53; 95% CI: 4.65-6.82 and OR=1.21; 95% CI: 1.16-2.27, respectively] (Table 4).

**Table 4. Univariate Estimated Odds Ratio of Medical Conditions for Hospitalized Drivers Compared to Elective Knee Replacement Controls**

| | Odds Ratio (OR) | 95% CI | | Estimate | Standard Error | P value |
|---|---|---|---|---|---|---|
| Vision and Hearing Loss | 0.68 | 0.63 | 0.72 | -0.3936 | 0.0351 | <.0001 |
| Cardiovascular Disease | 1.42 | 1.36 | 1.48 | 0.349 | 0.022 | <.0001 |
| Dementia | 2.39 | 2.24 | 2.55 | 0.8717 | 0.0332 | <.0001 |
| Metabolic Disease | 0.90 | 0.87 | 0.92 | -0.1079 | 0.0146 | <.0001 |
| Musculoskeletal Disease | 0.44 | 0.42 | 0.46 | -0.8264 | 0.0233 | <.0001 |
| Peripheral Vascular Disease | 1.17 | 1.07 | 1.28 | 0.1589 | 0.0448 | 0.0004 |
| Renal Disease | 5.63 | 4.65 | 6.82 | 1.7289 | 0.0977 | <.0001 |
| Respiratory Disease | 1.21 | 1.16 | 1.27 | 0.1929 | 0.0235 | <.0001 |

Matched on patient age, gender, race, insurance and ZIP code median income

Examining univariate associations of medical conditions among hospitalized drivers compared to the second control group, hospitalized adults in most frequent elective surgeries, for a number of conditions, the strength and direction of association remained intact, however for several others both the strength and the direction of the association shifted significantly. As when compared to elective knee replacement, vision and hearing loss [OR=0.91; 95% CI: 0.84-0.99], metabolic disease [OR=0.94; 95% CI: 0.91-0.96] and musco-skeletal diseases [OR=0.68; 95% CI: 0.64-0.73] were associated with a lower risk of a crash-related hospitalization. Similar to comparisons to the first control group, elective knee replacements, dementia was associated with a significantly higher risk of a crash-related hospitalization when compared to from top elective surgery controls [OR=2.21; 95% CI: 2.07-2.36].

Table 5 below reports univariate results when using hospitalized adults in most frequent elective surgery procedures as controls. In contrast to the first control group, cardiovascular disease was associated with a slightly lower risk of a crash-related hospitalization among older

drivers, when compared to controls in most frequent elective surgeries [OR=0.94; 95% CI: 0.90-0.99], showing a change in the direction of the association as when compared to controls in only in elective knee replacement hospitalizations. Furthermore, peripheral-vascular diseases and respiratory diseases also changed direction of association when compared to the second control group. Peripheral-vascular disease was associated with a significantly lower risk of a crash-related hospitalization [OR=0.67; 95% CI: 0.61-0.74], as was a diagnosis of respiratory disease [OR=0.92; 95% CI: 0.89-0.97]. While a diagnosis of renal disease remained in the same direction and was associated with an increased risk of crash-related hospitalization, it showed a significantly lower increase in the likelihood of a crash-related hospitalization compared to most frequent elective surgery controls [OR=1.93; 95% CI: 1.64-2.27] as when compared to elective knee replacements, with which comparisons renal disease was associated with a 563% increase in the risk of a crash-related hospitalization [OR=5.63; 95% CI: 4.65-6.82].

**Table 5. Univariate Estimated Odds Ratio of Medical Conditions for Hospitalized Drivers Compared to Most Frequent Elective Surgery Controls.**

| | Odds Ratio (OR) | 95% CI | | Estimate | Standard Error | P value |
|---|---|---|---|---|---|---|
| Vision and Hearing Loss | 0.91 | 0.84 | 0.99 | -0.0946 | 0.0404 | 0.0193 |
| Cardiovascular Disease | 0.94 | 0.90 | 0.99 | -0.0589 | 0.0228 | 0.0099 |
| Dementia | 2.21 | 2.07 | 2.36 | 0.7927 | 0.0338 | <.0001 |
| Metabolic Disease | 0.94 | 0.91 | 0.96 | -0.0676 | 0.0158 | <.0001 |
| Musculoskeletal Disease | 0.68 | 0.64 | 0.73 | -0.3834 | 0.0314 | <.0001 |
| Peripheral Vascular Disease | 0.67 | 0.61 | 0.74 | -0.3969 | 0.0481 | <.0001 |
| Renal Disease | 1.93 | 1.64 | 2.27 | 0.6586 | 0.0832 | <.0001 |
| Respiratory Disease | 0.92 | 0.89 | 0.97 | -0.079 | 0.022 | 0.0003 |

Matched on patient age, gender, race, insurance and ZIP code median income

A third comparison to all non-vehicle related crash hospitalizations is made to contrast the prevalence of driving-related medical conditions among hospitalized drivers to hospitalized groups that represent the true hospitalized population, rather than hospitalized groups most likely to be drivers, as was the intent for control groups 1 and 2. Univariate results show that crash hospitalized older drivers are significantly healthier than non-vehicle crash related hospitalized adult matched controls. Excluding vision and hearing loss conditions, all other driving-related medical conditions examined were significantly less likely to be identified among adults in crash-related hospitalizations than among non-crash hospitalized adults (Table 6).

**Table 6. Univariate Estimated Odds Ratio of Medical Conditions for Hospitalized drivers compared to All Non-Vehicle Crash Admission Controls**

| | Odds Ratio (OR) | 95% CI | | Estimate | Standard Error | P value |
|---|---|---|---|---|---|---|
| Vision and Hearing Loss | 0.96 | 0.90 | 1.02 | -0.0427 | 0.0312 | 0.17 |
| Cardiovascular Disease | 0.67 | 0.64 | 0.70 | -0.4052 | 0.0225 | <.0001 |
| Neurologic Disease | 0.49 | 0.47 | 0.52 | -0.7068 | 0.0234 | <.0001 |
| Metabolic Disease | 0.71 | 0.69 | 0.74 | -0.3366 | 0.0165 | <.0001 |
| Musco-skeletal Disease | 0.57 | 0.52 | 0.64 | -0.5548 | 0.0531 | <.0001 |
| Peripheral Vascular Disease | 0.51 | 0.47 | 0.55 | -0.6724 | 0.042 | <.0001 |
| Renal Disease | 0.41 | 0.37 | 0.45 | -0.8949 | 0.0474 | <.0001 |
| Respiratory Disease | 0.53 | 0.51 | 0.56 | -0.6279 | 0.0237 | <.0001 |

Matched on patient age, gender, race, insurance and ZIP code median income

### 3.2.2 Multivariate comparisons

In multivariate comparisons with matched patients hospitalized for elective knee replacements, representing the first control group, three groups of driving-related medical conditions, vision and hearing loss, metabolic diseases and musco-skeletal disease showed a significant association with a lower risk of a crash-related hospitalization. Vision and hearing loss was associated with a 30% reduction in the risk of a crash-related hospitalization [OR=0.70; 95% CI: 0.65-0.75],

metabolic diseases were associated with an 11% reduction [OR=0.89; 95% CI: 0.86-0.91] and musculoskeletal conditions were associated with a 56% reduction in the risk of a crash-related hospitalization, when compared to hospitalized controls in elective knee replacement [OR=0.44; 95% CI: 0.42-0.46].

Cardiovascular diseases were associated with a 40% increase in the risk of a crash-related hospitalization when compared to matched elective knee replacement hospitalized adults [OR=1.40; 95% CI: 1.34-1.46]. Dementia showed a significant association with an elevated risk of a crash-related hospitalization, with crash-related hospitalized adults being 2.5 times as likely as hospitalized controls to have a diagnosis of the condition [OR=2.40; 95% CI: 2.25-2.57]. Peripheral vascular disease, renal disease and respiratory disease showed an association with an increased risk of a crash-related hospitalization [OR=1.12; 95% CI: 1.02-1.23, OR=5.64; 95% CI: 4.68-6.80 and OR=1.19; 95% CI: 1.14-1.25, respectively] (Table 7).

**Table 7. Multivariate Estimated Odds Ratio of Medical Conditions for Hospitalized Drivers Compared to Elective Knee Replacement Controls**

| | Odds Ratio (OR) | 95% CI | | Estimate | Standard Error | P value |
|---|---|---|---|---|---|---|
| Vision and Hearing Loss | 0.70 | 0.65 | 0.75 | -0.3606 | 0.0357 | <.0001 |
| Cardiovascular Disease | 1.40 | 1.34 | 1.46 | 0.3332 | 0.0217 | <.0001 |
| Dementia | 2.40 | 2.25 | 2.57 | 0.8773 | 0.0336 | <.0001 |
| Metabolic Disease | 0.89 | 0.86 | 0.91 | -0.1188 | 0.0147 | <.0001 |
| Musculoskeletal Disease | 0.44 | 0.42 | 0.46 | -0.8309 | 0.0226 | <.0001 |
| Peripheral Vascular Disease | 1.12 | 1.02 | 1.23 | 0.1115 | 0.0479 | 0.02 |
| Renal Disease | 5.64 | 4.68 | 6.80 | 1.7299 | 0.0957 | <.0001 |
| Respiratory Disease | 1.19 | 1.14 | 1.25 | 0.1748 | 0.0238 | <.0001 |

Matched on patient age, gender, race, insurance and ZIP code median income

In multivariate comparisons with matched patients hospitalized for the most frequent elective surgeries, representing the second control group, as with univariate analyses, for conditions of vision and hearing loss, dementia, metabolic diseases, musco-skeletal diseases and renal diseases, the direction of the association and significance remained intact. When comparing hospitalized older drivers to matched patients in hospitalized elective surgeries, vision and hearing loss was associated with lower risk of a crash-related hospitalization [OR=0.92; 95% CI: 0.85-0.99]. As with elective knee replacement controls, dementia was associated with an increased risk of a crash-related hospitalization [OR=2.22; 95% CI: 2.08-2.38], whereas metabolic diseases, musculoskeletal conditions, as with the first control group, were associated with a lower risk of a crash-related hospitalization [OR=0.94; 95% CI: 0.91-0.97 and OR=0.66; 95% CI: 0.62-0.70, respectively].

Conversely, cardiovascular diseases were associated with a slightly lower risk of a crash-related hospitalization [OR=0.95; 95% CI: 0.91-0.99], representing a significant shift in the direction of the association, as when compared to elective knee replacement controls. Similarly, peripheral vascular disease was associated with a significantly lower risk of being in a crash-related hospitalization when compared to patients in the most frequent elective surgeries, a different finding than when compared to the elective knee replacement patients [OR=0.67; 95% CI: 0.61-0.74]. The direction of the association of respiratory conditions also changed, from an increased risk of a crash-related hospitalization when compared to the first control group, to a lower risk when compared to the elective surgery control group [OR=0.93; 95% CI: 0.89-0.97] (Table 8).

**Table 8. Multivariate Estimated Odds Ratio of Medical Conditions for Hospitalized drivers Compared to Most Frequent Elective Surgery Controls**

| | Odds Ratio (OR) | 95% CI | | Estimate | Standard Error | P value |
|---|---|---|---|---|---|---|
| Vision and Hearing Loss | 0.92 | 0.85 | 0.99 | -0.0811 | 0.0408 | 0.0465 |
| Cardiovascular Disease | 0.95 | 0.91 | 0.99 | -0.055 | 0.0228 | 0.0161 |
| Dementia | 2.22 | 2.08 | 2.38 | 0.7988 | 0.034 | <.0001 |
| Metabolic Disease | 0.94 | 0.91 | 0.97 | -0.0649 | 0.0159 | <.0001 |
| Musculoskeletal Disease | 0.66 | 0.62 | 0.70 | -0.4152 | 0.0298 | <.0001 |
| Peripheral Vascular Disease | 0.67 | 0.61 | 0.74 | -0.3939 | 0.0478 | <.0001 |
| Renal Disease | 2.00 | 1.69 | 2.36 | 0.6931 | 0.0853 | <.0001 |
| Respiratory Disease | 0.93 | 0.89 | 0.97 | -0.0713 | 0.0223 | 0.0014 |

Matched on patient age, gender, race, insurance and ZIP code median income

Finally, in multivariate comparisons with matched control hospitalized patients identified from a sample of all non-vehicle related admissions, the presence of medical conditions changes yet again. For example, the odds of a diagnosis of vision and hearing loss were not statically different between hospitalized drivers and hospitalized controls [OR=0.96; 95% CI: 0.74-1.23]. Furthermore, all other medical conditions examined were significantly less likely to be identified among hospitalized older drivers than hospitalized controls. Specifically, hospitalized drivers had 0.66 [OR=0.66; 95% CI: 0.57-0.77] 0.48 [OR=0.48; 95% CI: 0.40-0.58] and 0.74 [OR=0.74; 95% CI: 0.66-0.82] the odds of having a diagnosis of cardiovascular diseases, neurologic diseases and metabolic diseases, respectively, when compared to all non-vehicle related hospitalized controls. Similarly, the odds of musco-skeletal conditions [OR=0.56; 95% CI: 0.36-0.86], peripheral vascular diseases [OR=0.55; 95% CI: 0.41-0.74], renal diseases [OR=0.43;

95% CI: 0.30-0.62] as well as respiratory disease [OR=0.56; 95% CI: 0.48-0.64] were significantly lower for hospitalized drivers, than non-vehicle hospitalized controls (Table 9).

**Table 9. Multivariate Estimated Odds Ratio of Medical Conditions for Hospitalized drivers compared to All Non-Vehicle Crash Admission Controls**

| | Odds Ratio (OR) | 95% CI | | Estimate | Standard Error | P value |
|---|---|---|---|---|---|---|
| Vision and Hearing Loss | 0.96 | 0.74 | 1.23 | -0.046 | 0.1281 | 0.72 |
| Cardiovascular Disease | 0.66 | 0.57 | 0.77 | -0.4119 | 0.0761 | <.0001 |
| Neurologic Disease | 0.48 | 0.40 | 0.58 | -0.7285 | 0.0948 | <.0001 |
| Metabolic Disease | 0.74 | 0.66 | 0.82 | -0.3062 | 0.0548 | <.0001 |
| Musco-skeletal Disease | 0.56 | 0.36 | 0.86 | -0.5869 | 0.2217 | 0.0081 |
| Peripheral Vascular Disease | 0.55 | 0.41 | 0.74 | -0.5986 | 0.1486 | <.0001 |
| Renal Disease | 0.43 | 0.30 | 0.62 | -0.8476 | 0.1855 | <.0001 |
| Respiratory Disease | 0.56 | 0.48 | 0.64 | -0.5889 | 0.0738 | <.0001 |

Matched on patient age, gender, race, insurance and ZIP code median income

### 3.2.3 Association of Driving-Related Medical Conditions to In-hospital Death

One important outcome of crash-hospitalization is in-hospital death. Among hospitalized older drivers, a multivariate model, adjusting for driver's age, gender, and insurance status, and race, number of diagnoses, injury severity and income level was created to estimate the role of medical conditions on in-hospital death. Table 8 presents the results of this model. The results show that with every one year increase in hospitalized driver's age, when adjusting for other factors, the risk of in-hospital death increases by approximately 4 percent [OR=1.04; 95% CI: 1.01-1.06], and similarly a increase by one in the number of patient's diagnoses, including injury diagnoses, increased death risk by 9 percent [OR=1.09; 95% CI: 1.06-1.13]. Of note however is

the significant death risk associated by higher injury severity scores. For example, when compared to the baseline group of New Injury Severity Scores (NISS) under 10, those with scores of 10 to 19, were 3.7 times more likely to have died in-hospital, when adjusting for other factors mentioned above [OR=3.79; 95% CI: 2.63-5.45]. Furthermore, the in-hospital death risk for those with NISS scores above 19, when compared to the baseline group, was increased by 11.8 times, [OR=11.83; 95% CI: 7.70-18.7]. Interestingly, even when adjusting for the driver's age, injury severity, number of diagnoses and other medical conditions, female hospitalized drivers were significantly less likely to die in the hospital following a crash hospitalization, than their male counterparts [OR=0.49; 95% CI: 0.31-0.78].

When further looking at the association between driving-related medical conditions, after adjusting for driver's age, gender, insurance status, race, income, number of overall diagnoses as well as hospitalized drivers injury severity score, only hospitalized drivers with a diagnosis of cardiovascular disease were significantly more likely to suffer in-hospital death, compared to those without cardiovascular conditions. Specifically, hospitalized drivers with cardiovascular conditions were 2.1 times more likely to die in-hospital than those without the condition [OR=2.15; 95% CI: 1.13-4.08]. On the other hand, hospitalized drivers with a diagnosis of metabolic diseases were significantly less likely to die in-hospital compared to those without a diagnosis of any of the metabolic diseases specified [OR=0.45; 95% CI: 0.27-0.76] (Table 10).

**Table 10. Association of Driving-related Medical Conditions and In-hospital death**

| | Odds Ratio (OR) | 95% CI | | Estimate | Standard Error | P value |
|---|---|---|---|---|---|---|
| Age | 1.04 | 1.01 | 1.06 | 0.0369 | 0.013 | 0.0046 |
| Female | 0.49 | 0.31 | 0.78 | -0.7143 | 0.2352 | 0.0024 |
| Medicare | 1.26 | 0.88 | 1.81 | 0.2317 | 0.1837 | 0.2073 |
| White | 1.19 | 0.72 | 1.97 | 0.1765 | 0.255 | 0.4889 |
| Income ($39K – 47.9K vs. <38.9K) | 0.94 | 0.58 | 1.54 | -0.0613 | 0.2509 | |
| Income ($48K- 62.9K vs. <38.9K) | 0.62 | 0.33 | 1.16 | -0.483 | 0.3203 | 0.2109 |
| Income (>63K vs. <38.9K) | 1.06 | 0.56 | 2.01 | 0.0618 | 0.324 | |
| Injury Severity Score (10-19 vs. <10) | 3.79 | 2.63 | 5.45 | 1.3314 | 0.186 | <.0001 |
| Injury Severity Score (>19 vs. <10) | 11.83 | 7.70 | 18.17 | 2.4705 | 0.2191 | |
| Number of diagnoses | 1.09 | 1.06 | 1.13 | 0.087 | 0.0156 | <.0001 |
| Vision and Hearing Loss | 0.84 | 0.24 | 2.86 | -0.1808 | 0.628 | 0.7734 |
| Cardiovascular Disease | 2.15 | 1.13 | 4.08 | 0.7662 | 0.3268 | 0.019 |
| Dementia | 0.47 | 0.16 | 1.42 | -0.7512 | 0.5626 | 0.1818 |
| Metabolic Disease | 0.45 | 0.27 | 0.76 | -0.7924 | 0.2646 | 0.0028 |
| Musculoskeletal Disease | <0.001 | <0.001 | <0.001 | -12.6599 | 0.6761 | <.0001 |
| Peripheral Vascular Disease | 0.22 | 0.03 | 1.86 | -1.5158 | 1.0898 | 0.1642 |
| Renal Disease | 1.54 | 0.24 | 10.05 | 0.4299 | 0.958 | 0.6536 |
| Respiratory Disease | 1.50 | 0.79 | 2.84 | 0.4053 | 0.3263 | 0.2142 |

# 4.0 DISCUSSION

This study represents a first step in establishing a national prevalence of major driving-related medical conditions among senior drivers hospitalized due to a crash and examining the role of these conditions on crash-related hospitalizations, when compared to other populations. These findings also confirm that crash-related injuries represent a significant source of death, injury and disability for older adult drivers.

Of approximately 20,436 hospitalized older drivers, 5.4 percent died while in hospital and nearly 33 percent were transferred to other treatment facilities, including intermediate care facilities, rehabilitation facilities and long-term hospitals. Results also show that some 14 percent of hospitalized older adults suffer intracranial injuries, of which some 13 percent are considered Traumatic Brain Injuries (TBI). This study estimates that up to 50 percent of hospitalized adults will face difficulties in performing at least one activity of daily living (ADL) due to injuries suffered from a motor-vehicle crash. In total this study demonstrates the significant injuries sustained by older drivers in motor-vehicle crashes, the extensive burden due to such injuries as well as the elevated crash-related hospitalization risk associated with a number of medical conditions.

In an effort to more precisely compare the presence of driving-related medical conditions among the driving population, two control groups were selected to serve as comparators.

Hospitalized adults in elective knee replacement surgeries and hospitalized adults undergoing any of the most frequent elective procedures were identified as independent control groups. Given the sensitivity of estimates based on the controls chosen, two separate controls were intentionally chosen. Furthermore, two controls per case were identified and matched on five factors, described previously. This was done to ensure that estimates on the prevalence of these conditions among hospitalized adults can be compared to other populations, most likely to be active drivers.

This study showed that patients in crash-related hospitalizations were also likely to have been diagnosed with a number of medical conditions, considered to be related to driving ability (AMA 2010). As studies argue that metabolic conditions may increase crash risk, especially during acute phases of conditions such as diabetes, such conditions were examined (Weinger, Kinsley et al. 1999; Cox, Gonder-Frederick et al. 2000). Results show that an estimated 21.6% of hospitalized drivers also had a diagnosis of metabolic disorders, specifically controlled diabetes, uncontrolled diabetes or hypothyroidism. This compares to 19.1% for 65-74 year olds and 17.6% for those over 75 with diagnosed diabetes in the general population (CDC, 2009). However, when adjusting for age, gender and other factors and compared to controls in elective admissions, metabolic disorders were associated with a somewhat lower risk of a crash-related hospitalization [OR=0.94; 95% CI: 0.91-0.97], indicating that this condition may be underrepresented among the active drivers, compared to the general population. Similarly, a recent study by Songer et al., (2006) no significant relationship were found between diabetes complications, blood glucose control, diabetes treatment and subsequent motor vehicle crashes.

Neurologic diseases are another group of medical conditions that are often argued to negatively affect driving performance and that have received significant attention (Duchek, Carr

et al. 2003; Ott, Heindel et al. 2008) (Mola 1995; Lloyd, Cormack et al. 2001; Dobbs, Carr et al. 2002; Brown and Ott 2004; Martin, Marottoli et al. 2009). Studies report that drivers with severe dementia demonstrate more on-road driving errors than those with no dementia (Berndt, Clark et al. 2008) and have higher crash involvement than non-demented drivers (Tuokko, Tallman et al. 1995). Those with mild Alzheimer's disease have also been reported to perform poorly compared to study controls (Duchek, Carr et al. 2003). In this study, an estimated 1,446 (7.4%) hospitalized drivers were diagnosed with one of the conditions in the group of neurologic diseases, as specified by the AMA. Specifically regarding dementia estimates some 4.6 percent of those 65 and older had a diagnosis of dementia. A recent study by Plassman et al. (2007) put the prevalence of dementia in the general population at 5 percent for adults 71-79 years old, 24.2 percent for the 80-89 year olds and an estimated 37.4 percent for those over 90 years old. Comparing these estimates to our study's estimates of dementia among crash-related admissions some 4.4 percent of 71-79 year olds, 8 percent of 80-89 year olds and 4.1 percent of those over 90 had a diagnosis of dementia, significantly lower than Plassman estimates for the general population. However when examining the prevalence of dementia among hospitalized drivers to study controls, in all instances, dementia was associated with an increased risk of a crash-related hospitalization. This may demonstrate that while the prevalence of dementia among hospitalized drivers is lower than the general population, it is those in elective hospital admissions that are most likely to be active drivers, therefore serve as an adequate comparison group. Results showed that dementia was associated with a 2.2 times increased risk of a crash-related hospitalization [OR=2.22; 95% CI: 2.08-2.38],

Furthermore, study results also show that when comparing hospitalized older drivers to matched patients in hospitalized elective surgeries, vision and hearing loss was associated with

lower risk of a crash-related hospitalization [OR=0.92; 95% CI: 0.85-0.99]. Vision and hearing loss yielded consistent results when compared to the two control groups. As with elective knee replacement controls, metabolic diseases, musculoskeletal conditions, were associated with a lower risk of a crash-related hospitalization [OR=0.94; 95% CI: 0.91-0.97 and OR=0.66; 95% CI: 0.62-0.70, respectively].

Examining in-hospital death, there were significant differences in crash outcome based on the patient's underlying medical condition. Those diagnosed with a cardiovascular condition such as Myocardial infarction, Congestive Heart Failure, Valvular Disease, Cardiac Arrest or High grade Atrio-Ventricular (AV) block were 2.15 times more likely than those without the condition to die in the hospital [OR=2.15; 95% CI: 1.13-4.08]. Furthermore, approximately 10 percent of those with a diagnosis of neurologic conditions died in-hospital. Specifically, within this group, patients with a diagnosis of brain tumor had approximately a 1 in 3 in-hospital death rate, compared to 9 percent in-hospital death for those with similar diagnoses in elective hospitalizations.

Furthermore, the results show that with every one year increase in hospitalized driver's age, when adjusting for other factors, the risk of in-hospital death increases by approximately 4 percent [OR=1.04; 95% CI: 1.01-1.06], and similarly a increase by one in the number of patient's diagnoses, including injury diagnoses, increased death risk by 9 percent [OR=1.09; 95% CI: 1.06-1.13]. The risk of death was significantly lower for female drivers than male drivers [OR=0.49; 95% CI: 0.31-0.78].

# 5.0 SUMMARY OF FINDINGS

In this matched case-control study, we demonstrate the significant injuries sustained by older drivers in motor-vehicle crashes, the extensive burden due to such injuries and show that the prevalence of dementia among hospitalized drivers is up to 2.4 times higher than among hospitalized controls.

Beginning with the presence of driving-related medical conditions among hospitalized drivers, this study shows that driving-related medical conditions are commonly found among hospitalized drivers, with the prevalence of a number of conditions increasing with age, while decreasing for others. When compared to hospitalized control groups, we show that driving related medical conditions are not uniformly overrepresented among hospitalized drivers, with only the prevalence of dementia and renal diseases being overrepresented among hospitalized drivers, when compared to matched elective knee-replacement and matched all-elective surgery controls. This finding goes against our initial hypothesis that driving related medical conditions would be overrepresented among hospitalized drivers, than adults in elective surgeries. Conversely, with the exception of dementia and renal diseases, hospitalized older drivers were found to be healthier than all control groups.

The first two control groups were chosen in order to approximate the prevalence of conditions among non-hospitalized drivers. Hospitalized adults in elective-knee replacement

surgeries were the best group to represent non-hospitalized drivers. The second group, all elective-surgeries was a broader group that was meant to provide support to the results in the first comparison. A third comparison was made to all hospitalized adults to show that the first two control groups were indeed different from the general hospitalized population, hence provide support to their selection as control groups. Results that were consistent between the first two control groups showed that vision and hearing problems were significantly less prevalent among hospitalized drivers. Similarly, metabolic diseases and muscoskeletal diseases were also significantly underrepresented among hospitalized drivers, and showed consistent results between two control groups, after matching cases to controls on age, gender, race, insurance and ZIP code median income.

Finally, this study also examined the associated between driving-related medical conditions and in-hospital death. Results showed that after adjusting for driver's age, gender, race, income, number of diagnoses as well as injury severity only cardiovascular diseases increased the risk of in-hospital death for hospitalized drivers by 2.15 times, while metabolic conditions were shown to be associated with a lower risk of in-hospital death.

This study was a first attempt at characterizing the driving-related medical conditions among hospitalized adults and contrasting the prevalence of these conditions among hospitalized drivers to those among proxies of non-hospitalized drivers, namely hospitalized adults in elective procedures. Future studies that adequately ascertain the driving status of control groups may be required to provide additional support to the results of this study.

# 6.0 LIMITATIONS

This study has several limitations. First, as the prevalence of medical conditions is determined among drivers in crash-related hospitalizations, it may significantly differ from the prevalence of these conditions among drivers in fatal crashes, not transported to a medical facility, or drivers treated and released at the emergency department level and not subsequently admitted as inpatients to the hospital. Therefore, caution is warranted when applying these prevalence estimates to non-hospitalized drivers.

Second, while the estimates of medical conditions attempt to describe the characteristics of drivers in crash-related hospitalizations, the estimates cannot be parsed out for older drivers in at-fault crashes from those who were not at fault in crash leading to hospitalization.

Third, when engaging in comparisons to hospitalized groups to determine any difference in the prevalence of driving related conditions, it must be noted that among hospitalized drivers, driving related medical conditions may be under-reported, hence biasing the results to show a more healthy hospitalized drivers. This may be the case, as the principal and secondary diagnoses of a crash hospitalization tend to be occupied by injury related diagnoses rather than other medical, often chronic, conditions, which may be less likely to be recorded.

Fourth, the driving status of selected hospitalized controls cannot be determined and their prior crash history cannot be fully ascertained. While hospitalized control groups, hospitalized

adults in elective knee surgeries and hospitalized adults in all-elective surgeries, were selected as proxies for non-crashed adults most likely to be drivers, they may in fact be similar to the general population of older adults, who may not be drivers. Therefore, when interpreting the results on the differences on the prevalence of medical conditions between drivers in crash-related hospitalizations and hospitalized controls, it is important to bear in mind that hospitalized controls may be non-drivers, shifting the comparison from one examining the prevalence between crashed drivers and non-crashed drivers via hospitalized controls, to one between crashed drivers and non-crashed non-drivers.

A final limitation of this study, with significant implications on the direction of the odds ratio is what is termed as "Berkson's Bias". With regard to this case-control study, the selection of controls from the hospital setting, may amount to a selection bias, whereby the control population is not derived from the same populations as the cases, namely a population of driving adults from the general population. This limitation may limit the external validity of the study results to that of hospitalized controls, rather than the intended control, non-crashed driving adults. It is important to note, that while this bias cannot be fully adjusted without changes to the controls selected, measures such as matching to 2 controls as well as comparisons to 2 separate control groups, were taken to reduce the potential impact of this bias.

# 7.0 PUBLIC HEALTH SIGNIFICANCE

Given the changes to the driving demographic, renewed concern has arisen on the fitness of an aging driver population, and while previous studies highlight the relationship between functional and medical impairments and crash risk, no studies have directly estimated the prevalence of these conditions among the general driving population or among those involved in motor-vehicle crashes. There is a general lack of knowledge on the prevalence of driving-related physical and cognitive conditions among older adult drivers involved in crashes, the extent such prevalence is different from published estimates among the general population as well as among other comparable groups.

A number of attempts at characterizing medical conditions among the driving population were undertaken. In a 2002 study, McGwin et al. examined at-fault crashes and role of medical conditions, but conceded that due to low sample size (N= 901) prevalence for conditions such as epilepsy and Parkinson's disease were not reported (McGwin, Sims et al. 2000). A separate study by Dischinger et al., (2000), examining at-fault crashes only reported prevalence of a number of medical conditions among all adult hospitalized drivers in Maryland (Dischinger, Ho et al. 2000).

To address this gap, this study examined a nationally representative sample of crash-related hospitalized adults to estimate the prevalence of driving-related medical conditions.

Additionally, this study compared the prevalence of driving-related medical conditions among hospitalized older drivers to that of two comparison groups, in order to determine whether driving-related medical conditions are over-represented among hospitalized drivers. Third, this study also examined the injuries and in-hospital death outcomes of hospitalized older drivers with medical conditions, as compared to hospitalized drivers without medical conditions.

This study is the first study to report the prevalence of a broad range of driving-related medical conditions, among hospitalized drivers, using a national sample. This study directly informs federal, state and local governments on the medical conditions of their driving population and raises questions on the need for adequate reporting of driving-related medical conditions among the driving population. Furthermore, this study shows that dementia is significantly overrepresented among hospitalized drivers compared to control groups, thus highlighting a specific area of need for public health attention. The findings of this study carry immediate implication for the state practices of reporting of driving-related medical conditions, screening of drivers at the local motor-vehicle registries or at medical encounters. While the results suggest that drivers in crash-related hospitalizations are healthier than the general public, results show that a number of medical conditions are overrepresented among this group, especially when compared to control adults, most likely to be active drivers.

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